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A DISEASE OF THE BETEL VINE CAUSED BY A SPECIES OF *PHYTOPHTHORA*.

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THE Betel Vine or Sirih has been cultivated on a small scale in Malaya for many years. The plots are usually situated in the neighbourhood of towns or groups of estates employing Indian labour where a ready market is obtained for the sale of the leaves. The latter, along with a little lime and a few slices of areca-nut, form a masticatory which is in common use amongst the natives of Eastern countries.

In Pahang East, at Pekan, one of the main sources of income to the Malays is the growing of Sirih. The vines are grown in small plots, usually less than half an acre, in the ground surrounding the growers houses. The plants are grown 3—4 feet apart in rows, with 4 feet between each row and each vine is supported on a long pole from 10—12 feet high. Sirih has been grown in Pekan for more than 50 years and has provided a comfortable livelihood for the Malay cultivators. The leaves are all consumed locally and are sold under normal conditions at 8 cents per bundle of 50 leaves. At the end of 1923 the leaves were being sold at 40 cents a bundle owing to shortage of supplies, following a disease which appeared in the plots and killed most of the vines. During the North East monsoon, from October to December 1923, the rainfall at Pekan was continuous and heavy; over 72 inches being recorded for the three months. This was accompanied by a flood in the Pahang river which inundated the kampongs and Sirih plots.

Sirih requires plenty of water for its successful cultivation, but it is very susceptible to the effects of badly drained, waterlogged soil. Drainage at Pekan during the monsoon is difficult owing to the low lying situation, and by the end of January the Sirih vines began to die off rapidly. In March only a few vines were alive all through the district and specimens suitable for examination were difficult to obtain. Most of the roots were swarming with eel-worms and some of the roots had formed typical eel-worm nodules. Attempts to isolate a fungus were unsuccessful but bacteria developed freely. These however were non-pathogenic.

In October, 1924, the wet weather set in again at Pekan, 18½ inches of rain falling during the month. Minor floods appeared and the replanted Sirih vines began to die off rapidly. Good specimens in early stages of disease were obtained and examined. Sections cut from the stem at ground level, where the disease begins, were stained with cotton blue and lactic acid. Non-septate hyphae were evident running through the tissues and cultures prepared from similar sections yielded a *Phytophthora*, which later was obtained in pure culture.

Fungi reported on Piper Betel from other countries. In his report for 1903, Carruthers (1) in Ceylon mentions. "The disease of the betel pepper plant (Piper Betel. L.) was brought to my notice from different and widely separate districts. The disease is due to the ravages of a fungus of the family *Perenospora* in the softer tissues of the plant." This fungus does not seem to have been studied further. In 1906 Petch (2) in the Report of the Mycologist writes, "Several specimens of diseased betel leaves and shoots were sent in during the early part of the year." He does not mention any specific fungus but in the same report gives a list of fungi found on specimens and records *Cercospora* sp. on *Piper Betel. L.*

The following fungi have been recorded more recently on Sirih from Ceylon (3).

Leaf diseases:—

Colletotrichum Piperis	(Petch)
Oidium sp.	(Causing Mildew)
Phyllosticta Piperis	(Tarse)
Bacterial Disease.	

A *Cercospora* sp. and a *Colletotrichum* sp. have been found on the leaves in Malaya. They are associated with leaf spots but the damage done is inconsiderable.

In 1924 Mc Rae (4) mentions a disease of the betel vine connected with a *Fusarium* sp. and Hutchinson (5) records from Pusa a disease associated with bacteria in the xylem vessels of the stem. A species of *Diplodia* isolated for the first time from a wilted betel vine is reported by the Plant Pathologist, Bombay (6).

As far as available literature shows the above organisms are the only ones recorded as being associated with diseases of the betel vine. To this list must now be added a *Phytophthora* sp, causing a root and stem disease in Malaya.

Symptoms of the disease.—The disease is a typical "wilt" i. e. the leaves of the plant attacked either turn yellow and droop or droop while still green. The stem, which is rotted at the base, turns brown and withers. If a plant in an early stage of disease is examined, it will show that, in the majority of cases, the attack has commenced about an inch or so below ground level. At

this point the tissues of the stem are discoloured externally and internally. The colour varies from black to reddish brown and the internal tissues are soft and "gummy" with brownish red streaks. Later on the roots and stem disintegrate into a wet stringy slime and give off an acrid odour. In a few instances the disease appeared in a segment of the stem about a foot above ground level. The stem was ringed at this point by a discoloured area several inches long and the parts above this area wilted.

Conditions favouring the spread of the disease.—Waterlogged soil due to floods and defective drainage, heavy rains, and misty mornings, the presence of weeds and overhead shade form ideal conditions for an outbreak of a fungus disease. This is especially so when the fungus is a species of *Phytophthora*. On the East coast of Malaya from October to January floods are frequent and heavy rain falls almost every day. The Sirih plots are badly drained and are not kept free from weeds which in some cases grow to three feet high. It is not surprising therefore that once a plot becomes affected with *Phytophthora*, the disease spreads with great rapidity. The disease has only been reported from the East coast and has not been noticed in other districts where the cultivation of the betel vine is of a higher standard as described by Milsum (7).

Morphology.

Mycelium—The fungus grows well on the usual culture media, especially on maize agar. Mycelium is abundant and similar to mycelium of other species of *Phytophthora*, being coenocytic for the greater part of its growth and forming a few septae when old. The hyphae vary from 3 microns to 7 microns in width with a mean width of 5 microns. Aerial hyphae are sparingly branched and regular in outline ; the submerged hyphae are usually more branched and bear protuberances.

Sporangia.—These are produced in large numbers on all media tried. In shape they vary considerably, some being normally ovate with a prominent papilla, others curved, or tapering at base and apex and swollen in the centre. They may be borne either laterally, terminally or intercalary. The intercalar sporangia differ from chlamydospores in their irregular shape and from the fact that they frequently possess a papilla.

Production of zoospores.—This occurs after the sporangia are suspended in tap water at 25°–27°C for $\frac{1}{2}$ – 1 hour. No definite vesicle has been observed such as occurs normally in *Pythium*. The protoplasm splits up into zoospores which escape from the sporangium through the papilla. Two methods of liberation were observed. In one case the protoplasm when segmented, suddenly rotates inside the sporangium and the whole mass is expelled violently through the papilla. Once outside the zoospores separate almost immediately, although one or two may remain fused for ten or twenty seconds before separating, or they may remain fused and disintegrate. In the other case the zoospores emerge one at a time in the normal manner from the sporangium. Those which fail to emerge

may germinate inside the sporangium. The zoospores are not very active and rarely swim for more than a few minutes. They round off early and germinate quickly.

Zoospores measure from 12 microns to 16 microns in diameter when they round off. About 16—20 zoospores emerge from each sporangium and of these about one quarter disintegrate soon after emergence. The smaller sporangia are more apt to function as zoosporangia than the larger ones. Those sporangia measuring between 25 microns to 30 microns in length usually produce zoospores while the larger ones, germinate as conidia, producing germ tubes and forming secondary sporangia.

Size of Sporangia.—Measurements of sporangia were obtained from sporangia growing on maize-meal agar and green pea agar. No natural sporangia were obtained from the affected betel vines, but measurements were made of 60 sporangia grown on fresh rubber pods and areca nuts as a result of inoculation. Sporangia grown on maize and green pea agar were little different in size. Those obtained naturally from rubber pods and areca-nuts were slightly smaller. Measurements extended over a period of 3 months, care being taken to measure sporangia from 5 day old cultures on each occasion, as it was found that secondary sporangia were liable to be produced in older material. Up to the present 200 measurements have been made of sporangia from maize agar, the mean dimensions being

Length	- 41.99	±	0.479 microns.
Width	- 27.25	±	0.228 ,,
Standard deviation length	- 10.05	±	0.338 ,,
,, ,, width	- 4.79	±	0.162 ,,

Other measurements from 150 sporangia grown on green pea agar, 60 on rubber pods and 60 on areca nuts are

	Length	×	Width.
Green Pea Agar.	- 40.36	×	28.43 microns.
Rubber Pods	- 39.62	×	24.35 ,,
Areca Nuts	- 39.42	×	24.35 ,,

Chlamydospores.—These vary in diameter from 18—38 microns the mean for 100 measurements being 24.45 microns.

No sexual spores have yet been found either in culture or in nature although cultures were grown on maize, green pea, potato, and lima-bean agar and examined during eight months. A series of transfers of the fungus from one medium to another, single spore cultures, and mixing of cultures obtained from different inoculated hosts, is being tried to see if antheridia and oogonia will develop.

Inoculation Experiments.—The fungus has been proved to be parasitic on *Piper Betel* by means of inoculation experiments. These

inoculations have only been successful when the weather was continuously wet or when artificially moist conditions were set up.

I.—Shortly after the fungus was obtained in pure culture, six betel plants growing in pots were inoculated. Three of the plants were lightly wounded at soil level and mycelium, sporangia, and zoospores applied to the wounded surface. The remaining three plants were not wounded but were otherwise treated similarly. Six control plants were kept, three wounded and three unwounded. The weather continued wet during the experiment and at the end of nine days the inoculated, wounded plants all wilted. The unwounded plants remained apparently healthy for 13 days when two of them succumbed. The remaining plant did not show any signs of wilt after three weeks and all the controls remained healthy. The fungus was recovered from two of the wilted plants.

II.—A similar experiment with three wounded plants and three controls was made save that the plants were kept indoors during showers and were not watered. After 10 days the inoculated plants and controls began to droop and were then watered daily. All the plants recovered.

III.—During a period of dry weather three plants were wounded and inoculated. A pad of cotton wool was placed over the inoculation and kept moist for 10 days. All the plants wilted and controls remained normal.

IV.—One pot plant was put into a bath of water with water ½ inch above the level of the soil. After five days immersion the plant wilted.

V.—One pot plant was put into a bath of water, as in IV. and inoculated below soil level. After two days the plant was removed from the water and kept in the open air during dry weather. The plant wilted in six days and the fungus was recovered from the stem. A control was kept and the plant remained healthy.

VI.—Six young rubber pods were obtained and sterilised by soaking them for 10 minutes in corrosive sublimate solution (1 : 1000), and washing them in sterile water for a few moments. They were then wounded and placed in sterile glass dishes and inoculated with a suspension of the fungus in sterile water. After 4 days a slight aerial growth of mycelium and sporangia was produced and the pods rotted after 6 days.

VII.—A bunch of green areca-nuts was sterilised and treated as in VI. In 4 days a copious growth of mycelium and sporangia appeared over the nuts. Penetration of the mycelium into the nuts was slight.

VIII.—Three young papaya fruits were inoculated as in VI, no growth resulted.

IX.—Six "Brinjal" (*Solanum melongena*) fruits were treated as in VI, but became contaminated with moulds; no *Phytophthora* mycelium appeared.

X.—The tapping cuts of six rubber trees were inoculated with the fungus and the inoculation kept moist. No result.

XI.—Virgin bark of six rubber trees was scraped and inoculated. The inoculation was kept moist by fastening a watch glass, containing water, over the inoculation for a few days. A diseased patch similar to Patch Canker was produced after 14 days in 2 of the trees Controls were unaffected.

From the inoculation experiments enumerated above, it would appear that the fungus is not a vigorous parasite, save when climatic and soil conditions are favourable to its spread. This is also suggested by the behaviour of the fungus after it has been grown in culture for some months. When sub-cultured the fungus continues to grow vigorously, but inoculations indicate that it tends to lose its virulence. Furthermore the tendency of the sporangia is to germinate directly and zoospore production is difficult to bring about.

Taxonomy.—In this preliminary note it is not intended to discuss at length the systematic position of the fungus in the genus *Phytophthora*. The absence of antheridia and oogonia prevent the fungus being placed for the moment in the Cactorum or Phaseoli groups established by Rosenbaum (8). It is well known that environmental conditions exert a considerable influence on the size of sporangia of species of *Phytophthora*. A change of environment frequently results in an appreciable change in dimensions. This makes it a matter of some difficulty to assign a specific name to a *Phytophthora* isolated for the first time from a certain host.

It is necessary to grow the fungus in comparison with other known species under identical conditions and for a prolonged period before deciding whether it is a new species or an old one or a variety of an old one. The betel vine fungus is morphologically dissimilar to type cultures of *P. palmivora*, *P. Faberi*, and the Malayan Black Stripe and Patch Canker fungi, all of which have been grown in culture in this laboratory under identical conditions. Owing to lack of other type species it is not possible at present to deal with the matter. Further work is proposed along these lines.

NOTE:—Since going to press the writer has received the Review of Applied Mycology Vol. IV No. 12, December 1925, containing an abstract of the Report of the Government Mycologist (J. F. Dastur) Central Provinces India for 1923-1924. The report mentions a disease of *Piper Betel* due to a *Phytophthora* sp. causing losses amounting to 80% of the plantations.

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THE ACCELERATION OF VULCANISATION BY ALKALOIDS.

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Introduction.—It has previously been shewn by the authors* that the alkaloids of cinchona bark are useful accelerators of vulcanisation. The uncrystallizable residue left after the extraction of the principal alkaloids for medicinal purposes was also shown to be a vulcanisation accelerator. It was ascertained subsequently that this material, known as Quinoidine, had been used previously as an accelerator in rubber factories in the U. S. A. and more recently in Great Britain.

In view of the effect of organic nitrogenous substances as vulcanisation accelerators and our previous investigations on the Cinchona alkaloids referred to above, it was considered of interest to ascertain the effect of other alkaloids when mixed with raw rubber. This paper records the results obtained with cocaine, nicotine, emetine and hyoscine. In addition, since other investigations were being carried out on Ipecacuanha root, the effect of adding the powdered root of varying alkaloidal content, (emetine and allied alkaloids) was also investigated.

Experimental.—The alkaloids, as bases, were dissolved in alcohol, and the alcoholic solutions dropped slowly (spotted) over the surface of a definite weight of the creped sample of rubber so that the solution was entirely absorbed by the rubber. The rubber was then hung to allow the alcohol to evaporate.

The results of experiments with the above alkaloids are given in Table I below :—

Column 4 shows the percentage of alkaloid, calculated on the mixing of " rubber plus sulphur."

In all cases, except when otherwise stated, the mixing consisted of 90 parts of rubber and 10 parts of sulphur.

Table I.

Ref. No.	Type of Rubber.	Alkaloid.	Amount used per cent.	Optimum time of cure. Mins.
362 Ax	slab	Cocaine	0.1	64
Bx	,,	Nicotine	0.10	60
Cx	,,	Emetine	0.05	15
Dx	,,	Hyoscine	0.075	55
X	,,	Control	Nil	60
Ay	crepe	Cocaine	0.1	160
By	,,	Nicotine	0.10	160
Cy	,,	Emetine	0.05	40

*Journal Society of Chemical Industry Vol. XLI No. 24, December 30th 1922, pp 374T-376 T.

TABLE I.—(*Contd.*)

Ref. No.	Type of Rubber.	Alkaloid.	Amount used per cent.	Optimum time of cure. Mins.
362 Dy	crepe	Hyoscine	0 075	150
Y	,,	Control	Nil	160
Mc	,,	Emetine	0 0027	165
Oc	,,	,,	0.0054	120
Pc	,,	,,	0.0081	45
Sc	,,	,,	Nil	160
Tc	,,	Nicotine	0.45	140
Uc	,,	Nicotine	0.15	
		Emetine	0.0027	150

The results obtained from these experiments show that the alkaloids nicotine, hyoscine and cocaine, in the proportions used, have no effect on the rate of cure of the rubber, while emetine in very small quantities has a marked effect in accelerating the rate of cure.

A review of the above results, together with the results previously obtained for the Cinchona alkaloids, affords interesting information on the accelerating effect of nitrogen in these cyclic compounds. e. g. Nicotine, which is a piperidyl-pyridine, has no accelerating effect, while piperidine is a powerful accelerator.

The accelerating effect exhibited by emetine may possibly be accounted for by the position of the second nitrogen atom.

Ipecacuanha Root.—On account of the effect produced by emetine, experiments were continued on dried ground Ipecacuanha root and root bark, which at the time was being investigated in the laboratories. A series of experiments were carried out with root of different alkaloidal strength and also root bark of varying alkaloidal strength and fineness of grinding.

The results of these experiments are given in Table II.

GROUND WHOLE ROOT.

Varying percentages of six different samples of the whole ground root, after drying in partial vacuum for 12 hours at 50°C, were incorporated with the mixing of rubber and sulphur on the mixing rolls, in the percentages shewn in the table below.

TABLE II.

Ref. No.	Sample No.	Amount of root added (per cent.)	Optimum time of cure, Mins.
362 E	—	nil	150
,, Fa	1	4. 5	60
,, Fb	2	1	60
,, Ga	3	4.5	60
,, Gb	4	1.7	60
,, Ha	5	3.5	60
,, La	6	2	60

Ground Root Bark.

The root bark for this experiment was separated from the woody fibre of the whole root.

Ground bark from various samples was incorporated with the rubber-sulphur mixings in the percentages shown in the table below.

Table III.

Ref. No.	Sample No.	Amount of root bark added (per cent)	Optimum time of cure. Mins.
363 Ac	1 & 2 (mixed)	2.0	120
,, Bc	3	2.0	120
,, Cc	5	2.5	90
,, Dc	–	nil	160
,, Ec	1 & 2 (mixed)	2.0	125
,, Fc	3	1.5	110

Effect of Fineness of Grinding.

A further experiment was carried out with the object of ascertaining the effect of the fineness of grinding of the root bark on the acceleration in rate of cure.

The table below gives the results of this experiment.

Table IV.

Ref. No.	Amount of Root bark (per cent.)	Fineness.	Optimum time of cure. Mins.
366 A	Nil		210
,, B	1.5	$\frac{1}{100}$ inch	150
,, C	3.5	$\frac{1}{100}$ inch	135
,, D	2.5	1 mm	160
,, E	3.5	1 mm	150

The above results indicate the importance and influence of fine grinding.

Effect of the Addition of Zinc Oxide.

In Expts. 364 and 367, zinc oxide was added to the mixing in order to ascertain whether any additional accelerating effect would be produced.

The following table shows the mixings used and the optimum times of cure. The amounts of zinc oxide and root bark are calculated on the mixing of "rubber plus sulphur." The bark (sample No. 5 as used in Expt. 362) was ground to a fineness of $\frac{1}{100}$ inch and dried in vacuo. The alkaloidal content of the bark was 2.77 per cent.

The crepe rubber was from the bulked sample used in Expts. 361 and 366 and the bark from samples 1 and 2 used in Expt. 366.

TABLE V.

Ref. No.	Zinc oxide (per cent).	Bark (per cent).	Optimum time of cure. Mins.
364 A	Nil	Nil	180
,, B	4.0	Nil	120
,, C	Nil	1.0	150
,, D	4.0	1.5	60
367 A	Nil	Nil	210
,, B	Nil	1.5	165
,, C	Nil	2.5	150
,, D	Nil	Nil	140
,, E	Nil	5.0	125
,, M	Nil	2.0	150
,, N	Nil	4.5	125
,, F	4.0	Nil	160
,, G	4.0	0.5	105
,, H	4.0	1.0	75
,, K	4.0	1.5	50
,, L	4.0	3.5	30

The above results indicate that the zinc oxide has an effect in augmenting the acceleration of cure produced by emetine.

EVALUATION OF ROOT BARK BY VULCANISATION TESTS.

The following experiments (Nos 368 & 369) were carried out as an attempt to evaluate the Ipecacuanha root by means of the accelerating effect on the rate of cure of rubber. The results are tabulated in the table below.

The various root barks used in these experiments (Nos. 368 and 369) were ground to 1/100 inch and dried in vaccuo for 24 hours at 60°C.

The total alkaloidal content of each sample was determined and found to be as follows:—

Sample 1–2 (Mixed) - 2.77 per cent.
,, 4 ,, - 2.9 ,,
,, 11 ,, - 1.85 ,,

The following table gives the amounts used and the results obtained:—

TABLE VI.

Ref. No.	Sample used.	Amount used (per cent.)	Amount of Total Alkaloid on Mixing (per cent)	Optimum time of cure Mins.
368 A	—	*Nil*	0.0	180
,, B	Nos. 1 & 2	1.0	0.0277	145
,, C	No. 11	1.0	0.0185	150
,, D	No. 4	1.0	0.0294	150

Ref. No.	Sample used.	Amount used (per cent.)	Amount of Total Alkaloid on Mixing (per cent.)	Optimum time of cure Mins.
369 A	—	*Nil*	0.0	195
„ B	Nos. 1 & 2	1.9	0.0526	130
„ C	No. 4	1.9	0.0559	130
„ D	No. 11	1.9	0.0351	135

The results show that, although the rate of cure generally varies with the amount of total alkaloid used, within the limits of the quantities used, the rates of cure do not sufficiently indicate the value of the root bark in respect of the amount of alkaloid present.

No reference is made here to the effect of the addition of powdered Ipecacuanha root on the tensile properties of the vulcanizate, since the results will be incorporated in a paper to be published subsequently, on the variations in tensile strength of vulcanised rubber.

Summary.

This investigation shows that, of the alkaloids examined, only emetine acts as a vulcanisation accelerator. It is also shown that Ipecacuanha root and root bark act as vulcanisation accelerators and it is possible that residues, after the extraction of emetine from this material, may be of value as vulcanisation accelerators, although the amount of material available on the market is probably not large. (cp. application and use of Quinoidine from cinchona bark as a vulcanisation accelerator.)

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EPIPHYTES ON CULTIVATED TREES.

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AS certain epiphytes found on cultivated trees locally are often mistaken for parasitic plants, it may perhaps be useful to describe briefly some of them and the manner of their growth in the lowlands of Malaya.

An epiphyte, as it's name implies, is a plant which grows on other plants, but it is not parasitic on them and is not usually attached to the soil. It is sometimes termed an air-plant. In the hot humid climate of Malaya, epiphytes occur in large numbers on numerous jungle and cultivated trees so that trunks and branches and even twigs and leaves are often completely covered with them. They belong to widely dissimilar classes of plants, such as lichens, mosses, ferns, orchids and other flowering plants; but the most noteworthy, from a planter's standpoint, are several species of fern and certain flowering plants. These air-plants occupy various sites on trees and may be observed growing in the forks of branches; in depressions caused by or following wounds: on the rough bark of dicotyledonous trees, on the smooth stems of coconut and other palms; and also at the bases of the leaves of palms more especially those species whose leaves remain attached to the stem for long periods, such as, for example, the African Oil Palm (*Elaeis guineensis*, Jacq).

The epiphytes on cultivated trees thrive better in sheltered places where the rainfall is heavy or well distributed and where there is a certain amount of overhead shade than elsewhere, and further, these air-plants generally possess specialized organs which enable them to exist in the peculiar situations they occupy even when water is scarce. Among the devices for storing and conserving water during dry periods are thick and fleshy leaves, thick cuticles, sunken stomata or breathing pores, swollen stems, enlarged leaf-bases and roots covered with a thick spongy covering by means of which water is absorbed and retained as in most epiphytic orchids and aroids.

Most air-plants possess suitable mechanisms which enable their spores and seed to be successfully disseminated. By means of these they can reach new sites and carry on their existence. Their spores and seed are particularly well adapted for dispersal by the wind and by birds, and these are the chief agents, as far as is known, which carry the spores and seed from place to place.

The young plants even in the earliest stages of growth are able to fasten themselves securely to their supports by means of clinging or anchoring roots, so that they are not easily detached from the sites they occupy.

Epiphytes obtain their mineral food substances from decaying organic matter (humus) and not from the plants on which they grow.

This humus is derived from dead leaves and other plant débris which collects around the plants. Some air-plants, e.g., certain species of orchid, have their roots so interwoven in a loose net-like manner that these serve to collect organic matter as it becomes available. Again some of the large ferns such as the Oak-leaved Fern (*Drynaria quercifolia, L.*) and the Stag's Horn Ferns (*Platycerium spp.*) produce peculiar leaves which are arranged in the form of a pocket against the trunk or branch of the supporting tree in which humus is retained, whilst the Bird's Nest Fern (*Asplenium nidus*, L) has its leaves arranged in a rosette, the bases of which slope inwards to form a funnel in which food material collects.

As a rule, numerous roots are produced but these serve only to anchor the plant securely to stem or branch and to absorb food as it becomes available from the sources already described; they are not able to enter the living tissues of the trees on which they grow to secure food materials; therefore, epiphytes, unlike mistletoes, are not capable of parasitizing cultivated trees.

The chief local epiphytes on useful trees may be classed under three heads, (a) true epiphytes, (b) half epiphytes, and (c) nest epiphytes.

True Epiphytes are plants which are able to obtain all their food and water from the surface of the supporting tree and from the atmosphere. In this class may be placed numerous flowering plants notably orchids and ferns. Good examples of these are the Pigeon Orchid (*Dendrobium crumenatum*, Swartz) and the common Sakat ribu-ribu (*Drymoglossum heterophyllum*, L.) It should be mentioned, however, that numerous plants which thrive epiphytically, more particularly many species of fern, are often able to grow equally well on the ground. *Half Epiphytes* are air-plants which pass through their earlier stage of development on trees, but subsequently become connected with the ground. Excellent types of these are furnished by species of Fig, such as the Banyan Fig (*Ficus bengalensis*, L.) *Ficus Benjamina*, L., *F. indica*, L., *F. elastica*, Roxb., and others. The seed of these germinate on the trees and the young plants at the outset have to subsist on such food materials as occur in the hollows and crevices of the bark of the tree on which they grow until their long aerial roots reach the soil. Whilst *Nest Epiphytes* comprise plants which, as mentioned above, collect humus in pockets or funnels by means of specialized leaves arranged in a particularly and effective manner.

Among the true epiphytes found on useful trees which may cause damage if allowed to over-run them, particular mention should be made of the common creeping ferns, *Drymoglossum heterophyllum*, L., and *Cyclophorus adnascens*, Desv., and the small creeping flowering plant *Dischidia Gaudichaudi*, Dene.

The fern *Drymoglossum heterophyllum*, L., (Plate 1) known to the Malays as Sakat ribu-ribu, is very commonly found on rubber, coconut, fruit and shade trees. It has a long slender creeping rhizome with fronds of two kinds, barren and fertile. The barren

frond, which as a rule lies flat against the stem of the supporting tree, is roundish or oblong, leathery, fleshy, and is either almost sessile or shortly stalked. The apex of the leaf is rounded, the edge entire with the base obliquely or regularly wedge-shaped. The fertile frond is much longer, narrower, and with a longer stalk than the barren one, and does not rest against the stem or branch of the host tree. The sori which contain the spores are arranged in dense broad marginal lines on the under surface of the frond and may cover the whole of it.

This fern is often seen almost covering completely the stems of palms such as the Coconut (*Cocos nucifera*, L.,) and the Pinang (*Areca catechu*, L.,) and the trunks, branches and twigs of fruit trees.

Frequently found associated with *Drymoglossum* is the other small creeping fern, *Cyclophorus adnascens*, Desv., (Plate III A.) This also has a long thin creeping rhizome and dimorphous fronds. The barren frond is oblong, linear or spathulate, leathery and short stalked. The apex is blunt, the edge entire and the base gradually narrowed. The fertile frond is shortly stalked, linear and larger than the barren one, and has its edges more or less curved. The sori are small and occupy the upper half of the frond. This fern may be easily mistaken for a form of *Drymoglossum*, but its narrower, longer and somewhat thinner barren fronds which do not lie flat against the stem of the tree easily serve to distinguish it from the latter.

The other plant mentioned, namely the Asclepiad (*Dischidia Gaudichaudi* Dene.) (Plate II) which is sometimes termed 'Petis' locally, also has a slender climbing stem rooting at the nodes. It has small fleshy opposite ellipsoid leaves which lie flat against the stems of the supporting trees. They become thick and turn yellow in colour in exposed air situations. The flower is small and white. The fruit is 1¼ inches long and very narrow and contains several small plumed seeds. This plant grows rapidly and quickly covers the stems, twigs and leaves of fruit and other trees and damages them severely if allowed to remain.

Some of the half-epiphytes, namely, certain species of Ficus, or the Ara trees of the Malays, (Plate V) are capable of destroying useful trees by means of their strangling aerial roots and the overhead shade of their leaves. The fruit of these figs is sought after by birds an possibly bats and readily disseminated by them. It is no uncommon sight to see fig plants growing well on the towers and roofs of lofty buildings as well as on high trees, to which sites the fruit had been originally carried by birds or bats. At the outset the young plants have to subsist on any food they can obtain in the cracks and crannies of their supports, until their long rope-like aerial roots reach the ground and obtain food materials from the soil. On trees other branching roots encircle the stems and by pressure resulting from growth have a strangling effect on them, whilst the leafy growth of the branches of the epiphytes has a devitalizing effect also, owing to the thick shade formed so that the supporting trees are gradually killed.

In regard to the nest-epiphytes which include several species of fern, such as the Oak-leaved Fern (*Drynara quercifolia*, L.,) (Plate IV) the Bird's Nest Fern (*Asplenium nidus*, L.,); and the Stag's Horn Ferns (Platycerium spp.) these may not be capable of damaging useful trees to the same extent as the species described in the other classes, still they are often seen in the hollows or covering stems and branches below which are damaged or wounded areas, and by retaining plant débris and moisture they may hasten the decay of stem or branch.

Although the superficial and herbaceous character of the growth of many of the epiphytes is not harmful provided such growth does not cover wounded or diseased areas, or the twigs, leaves and inflorescences of the supporting trees, yet, as has been shown, several species are capable of causing quite extensive damage if allowed to develope. It is desirable, therefore, to remove all epiphytes, especially those on rubber and fruit trees, if this can be done without injury to the trees. As a general rule, epiphytes should be treated as weeds and removed as soon as seen, because after certain of them have made extensive growth their successful eradication becomes a very difficult and expensive operation. It is recorded from India that following the removal of epiphytic growths from the trunks of rubber trees that patch-canker was more prevalent than before and caused much damage, so that when detaching epiphytes care should be taken that the bark of the trees is not injured.

In the case of coconuts it is no uncommon sight to see the creeping ferns *Drymoglossum heterophyllum* and *Cyclophorus adnascens* almost completely covering the upper portions of the stems of large numbers of old palms in plantations and gardens. Although so common, these ferns rarely appear to extend above the bases of the leaves of the coconut palm and reach the inflorescences so that it is doubtful if they are capable of causing any damage to this tree. On the other hand, African Oil Palms (*Elaeis guineensis*, Jacq.,) are frequently seen with their inflorescences and fruit almost completely covered by strong growing epiphytic ferns such as *Nephrolepis exaltata* L., *N. acutifolia*, Dene, and other species.

When writing the earlier portion of this article reference was made to (a) Dr. A. F. W. Schimper's Plant Geography (1903); and (b) Dr. J. C. Willis' Flowering Plants and Ferns (1908).

SUMMARY.

1. A short account is given of the life history of epiphytes on useful trees in the lowlands of Malaya.

2. Certain common epiphytic flowering plants and ferns which frequently damage cultivated trees are described.

3. Careful and early removal of these epiphytic growths from trees in plantations and gardens is advised.

References to Plates.

Plate I. The fern, *Drymoglossum heterophyllum* L., on the stem of an African Oil Palm (*Elaeis guineensis* Jacq.)

Plate II. A mass of the creeping Asclepiad (*Dischidia Gaudichaudi*, Dene), at left, on a Carambola tree (*Averrhoa Carambola* L.)

Plate III. Three climbing epiphytes which are capable of damaging useful trees. A.—*Cyclophorus adnascens*, Desv. ; B.—*Drymoglossum heterophyllum L.* ; and

C.—*Dischidia Gaudichaudi Dene.* The longer and narrower spore bearing leaves of A & B can be readily distinguished.

Plate IV. A nest-epiphyte, *Drynaria quercifolia L.*, showing the specialized leaves which collect plant débris arranged as a pocket at the base of the plant and an ordinary frond above.

Plate V. A young fig (Ara) tree (*Ficus Benjamina*, L.,) at right commencing to strangle a Durian tree (*Durio zibethinus*, L.,)

Plate VI. A typical Drymoglossum—Cyclophorus association on a Saman tree (*Enterolobium Saman Prain*), Mainly *Cyclophorus adnascens* above, and *Drymoglossum heterophyllum* below.

REPORT ON LONGEVITY OF HEVEA BRASILIENSIS.

F. G. Spring.

OPINIONS have been expressed (see editorial, The Straits Times, Saturday, January 9, 1926), "That a considerable proportion of the rubber in Malaya is now past its prime, which we should put at from 12 to 15 years. Bark renewal will not be as good. . . ."

The opinion of this Department is contrary to the above, in fact, directly contrary on estates where the rubber is grown under good environmental conditions. Even on estates where enviroment cannot be considered first class, the experience of the Department is not reflected in the above opinion, which might apply to estates where proper care to ensure soil fertility has not been taken.

Observations on the longevity of *Hevea brasiliensis* are being recorded and yields are being taken on trees around 30 years of age. The results, up to date, indicate that when depreciating yields per acre are found, the true cause lies not in the age of the tree but in bad environmental conditions brought about by a number of causes such as soil erosion, severity and quality of tapping, bad soil moisture conditions, impoverished soils and disease.

The problem of longevity of rubber trees is an extremely difficult one as there are so many influencing factors which require to be considered. What the rubber producer in the East is concerned with, is the commercial life of a tree growing under plantation conditions. The subject to be dealt with first is in respect of trees growing in their natural habitat, the Amazon region of South America.

Longevity of rubber trees in Brazil.—The age which Hevea attains in the virgin forests of Brazil is not known and it is only possible to form an idea thereof from the circumference of old trees. The following is a translation from the Archief Voor de Rubber Cultuur 1921, page 21. "Uli states that Hevea in its natural habitat attains a height of 40 meters—(say 130 ft.) and a girth of 5 meters (say 16½ ft.). Akers gives a photo of a Hevea of Mirary on the Madiera river with a circumference of 266 inches at a height of 3 feet. Even considering that Hevea is a quick growing tree, it will not be far wrong to estimate the age of such a gigantic tree at a century at least." Lock refers to *Hevea brasiliensis* as often reaching a height of 90 feet whilst the circumference near the ground may exceed 12 feet and Wickham reports that under favourable conditions it attains a girth in the trunk of 12 feet. Pinching in his report on this subject quotes from Akers "The Rubber Industry" (page 73) as follows.—"The girth of forest grown rubber trees varies to a marked degree in different localities of the Amazon valley. For mature trees it ranges from 50 to 200 inches in circumference measured at a height of 3 feet from the base of the trunk. Occasional

examples occur of the girth attaining such colossal dimensions as 300 inches. It is safe to consider the average girth of estrada trees in tapping as 100 inches or thereabouts and the average height 100 feet approximately. The age of the trees is extremely difficult to gauge with any degree of accuracy, owing to the absence of all reliable records in this direction. In the Madiera districts and elsewhere many trees are found that have been tapped for sixty years past, therefore they are probably not less than eighty years old, but the growth and development is so far influenced by surrounding conditions of locality, light, air, soil and exposure, that size cannot be regarded as a criterion of age." From observations made by Irving, "The Rubber Industry" Torrey and Manders, page 45, twenty to thirty years seems to be the very least that could be expected to produce a tree of tappable dimensions growing under forest conditions. Heavy underbrush retards the growth of a tree in the early stages of growth but makes of it a very hardy member of the forest tribe, no doubt a question of the survival of the fittest. In the India Rubber World, Vol. LV, No. 4, January 1917, page 209, the following particulars are given of a big Hevea tree in South America, stated to be probably the largest in the world by J. Simao da Costa in a letter dated Para, December 1916, to the Editor of the India Rubber World. This tree is 127 feet in circumference at the base and has a record of yielding for 120 days at the average of 22 lbs. of rubber per day. The tree is situated in Brazil and is exploited by a whole family—father, mother and several children—which divides its time between cultivating cereals for food and extracting the latex from this tree. It is said not to be the only giant tree in the region, in fact there are thousands but this is the largest being tapped. The land in the district is considerably higher than the surrounding land and the writer concludes that it was from the seeds of these trees that the Hevea found its way east and south of Brazil, since native Hevea is found as far south as the seventeenth degree, and as far east as the south of Maranhao. The writer expresses the opinion that this tree must have been growing long before Columbus discovered America.

Longevity of rubber trees under plantation conditions in the East.—The longevity of a field of Hevea cannot be arrived at with any degree of certainty. The following factors may have direct influence on the span of life of the trees. (1) Introduction of the crop into another country. Although Hevea appears to be admirably suited to Malayan conditions it is difficult to say what effect there may be on the life of the tree when it becomes acclimatized to conditions other than those of its natural habitat. (2) Fungoid diseases and insect pests, (3) Soil conditions and deterioration of the soil by surface erosion or other causes, (4) Planting conditions e.g. distance of planting and drainage and (5) Past treatment of the trees in respect of tapping and pruning.

It will be of interest to review the earliest plantings in the East. Unfortunately no careful records of some of those in Malaya were kept consequently it is difficult to ascertain the exact age of the respective plantings.

In the Gardens Bulletin, S. S. Vol. I, No. 8, information is given regarding the introduction of Hevea into the Colony. The first consignment from Kew of Hevea seedlings reached Singapore Botanic Gardens, in 1876. Some were saved for at least a year but no record exists showing their further history. Twenty two seedlings, a second consignment, sent a year later, arrived in June, 1877, and more than half of the number was planted in the Botanic Gardens. Nine plants were taken to Kuala Kangsar and planted behind the Residency. The first tree to flower in the East appears to be one of these nine trees for it is recorded that a tree at Kuala Kangsar flowered in March, 1880, at the age of 3½ years but did not set fruit until its third flowering in 1881. Probably in 1883 trees first fruited in Singapore. The Singapore seed crop was at first used up between the Botanic Gardens, Singapore, Sarawak, Kuala Kangsar, Kuala Lumpur, and Malacca. The smaller Kuala Kangsar crop increased the local plantation and supplied the seedlings which became widely distributed there and over Perak and others in Selangor and Negri Sembilan.

I inspected a few of the old Kuala Kangsar trees on 19-4-25. The trees are healthy looking in appearance and have fine branch and leaf development. They are now 42 years of age, and in spite of excessive over tapping in former years they look as if they will live for many years yet. These trees have not been tapped for several years.

Most the old trees on Welds Road, Kuala Lumpur, said to be planted between they ears 1895 and 1899 have been cut out. I examined two of those remaining. No. 1 has a girth of 6 feet 9 inches measured 3 feet from the ground and contains 24 latex vessel rows, one foot from the base while tree No. 2 has a girth of 6 feet and 11 latex rings at similar heights. The trees look healthy and one of them has excellent branch and leaf growth.

In October, 1898, 1306 rubber seedlings were planted out near the Offices of the Department of Agriculture, F. M. S., and S. S. spacing 18 ft. by 18 ft.

The trees were raised from seedlings obtained from the Botanic Gardens, Singapore. A record was kept of the yield of a group of 48 of these trees during the year 1923 and found to be 412 lbs. of No. 1 rubber. The number of trees to the acre in 1923 was 65. The average girth measured 3 feet from the ground on 21.5.25, was 55 inches. As is common with other old areas the trees have been most severely tapped in past years and considering all things I think the yield of these 27 year old trees is satisfactory as it works out at 558 lbs. of No. 1 rubber per acre, per annum.

The first plantation in Ceylon is from the original seed procured by Wickham from the Amazon in 1876 and particulars are given in Bulletin No. 4, Hevea, Yields of some Heneratgoda Trees, published by the Department of Agriculture, Ceylon. The plants reached

Ceylon towards the end of that year, and were planted at Henaratgoda in 1877. The Plantation contains 40 trees planted irregularly. The second plantation was established about ten years later, in about 1886 with seed from the original trees. One tree at Henaratgoda known as No. 2, planted in 1877, has a circumference of 137 inches at 3 feet from the ground. It is reported that some of the original 1876 trees of Wickham's stock are still living in Ceylon in the Experimental Gardens at Peradeniya and Henaratgoda. In Lower Burma, at Mergui on the property belonging to Mergui Crown Rubber Co., many of the original trees sent over from Ceylon, in 1878 still flourish.

General Remarks.

The rubber plantation industry is not sufficiently old to enable one to say what the length of life of Hevea may be, or even to state, with any degree of accuracy, the period over which a field of rubber trees will continue to yield a supply of latex sufficient to make it a paying proposition. One of the chief factors to be reckoned with is disease. Many of our old trees have been lost by fungoid diseases and insect attacks. In areas which have been severely thinned out one cannot afford to keep on losing trees year after year as there might then come a time when the number of trees to the acre is so small that a replanting programme may be necessary. Special supervision in such fields is required in order to endeavour to maintain the number of trees, per acre, at a reasonable standard. The replanting of diseased areas is a matter for investigation but it does not come within the scope of this report.

Soil erosion is another factor which may have a direct influence on the life of a tree. It is not reasonable to expect trees to continue to flourish in badly washed and impoverished soils for as long a period as trees growing in fertile soil conditions. Fortunately, however, most estates are now taking precautions to reduce soil erosion to a minimum.

The question of bark renewal is most important. In the "Third Report of the Executive Committee to the Members of the Rubber Research Scheme, Ceylon, Petch writes," An inspection of some of the oldest trees in Ceylon has been made for the purpose of estimating the probable life of rubber trees under estate conditions. It would appear that after 30 years of age bark renewal is very slow and the power of recuperation of the trees is much less than with younger trees. However, from the examination made it was not possible to make any determination of the probable life of rubber trees in Ceylon."

In the same publication Taylor states, "An examination of the trees on the old Government Plantations at Yatipauwa and Edangoda has been made with the view to securing some estimation of the probable life of Hevea under estate conditions. These trees have received varied and somewhat severe treatment, and it is probable that under present conditions the life would be materially prolonged. Without further information than that furnished by these trees it

is not possible to estimate the probable economic life of Hevea in Ceylon."

Practically all old trees have been severely tapped in the past and it is likely that better cultivation of the estates, conservation of the surface soil, conservative systems of tapping and good quality tapping will result in a longer period of increased yields but it should be remembered that plantation trees may possibly show signs of age earlier than trees growing in their natural habitat.

It is proposed to publish further information on yields from the oldest trees in Malaya, grown under varying conditions at a later date.

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RUBBER IN THE N. E. I.

A Medan View.

The following article is taken from the Netherland Indies Review No. 7, Dec. 1925. In view of the interest recently displayed in an authoritative tabulation of production figures, more especially of native production, it is thought that the figures given will prove of value.

Writing in the Rubber Quarterly, the Medan correspondent of that journal says:—

"The tremendous rise which the price of rubber has shown, and the high level at which this price is maintained, has given rise to excesses in the Dutch East Indies. In the districts where rubber is tapped, the wages have risen to such a degree that no labour is to be found for other occupations. The coolies engaged in tapping earn enough to indulge in various luxuries, such as automobiles, expensive trinkets, etc. No attempt to save is made except in a very few cases, the result being, of course, that the natives are exploited by European dealers, who import large amounts of worthless trash which is purchased for good money.

Production Figures.

"As regards rubber culture in the Dutch East Indies, some official figures have lately been made public which give a good insight into the extent and importance of Dutch productive territory. The area, planted with rubber trees, of the 836 Hevea enterprises amounted at the end of 1924 to 555,124 bouws (one bouw is equal to 1.754 acres). The data showed that the rubber trees planted become productive on the average in about seven years. The production of Hevea Plantation Rubber in 1921 amounted to 90,291 metric tons.* For the year 1925 the rubber harvest may be estimated at 96,082 tons from 693 producing enterprises. For the whole of the Dutch East Indies the production in 1924 was 233 kilos per bouw, as against 231 kilos for the previous year, and only 194 kilos in 1921. With a correction for loss by washing, estimated by the Central Rubber Station at Buitenzorg, the production figures for native rubber, free from water and dirt, are estimated for 1923 at 35,700 tons, for 1924 at 56,293 tons, and for 1925 at 73,400 tons. At the present price level for native rubber a rise or fall in quotations does not have any noticeable influence on the quantity of rubber shipped.

Planted Areas.

"Of the area planted by the various enterprises more than 30 per cent, is not yet productive, while of the balance there is still much young rubber that has just been tapped; 46 per cent of the amount planted is under ten years old. The native rubber has of late

* Metric tons are given throughout. One metric ton is equal to 1000 kg. or 2205 lbs.

years increased very much in importance, both relatively and absolutely.

"At the end of 1923 the area planted with rubber in the Dutch East Indies, in possession of British subjects, amounted to 304,991 acres, and at the end of 1924 to 310,223 acres, according to the data of the Rubber Growers' Association, voluntary restriction was practised in 1923 by 257,504 acres, or 88 per cent of the total area planted, and in 1924 by 249,145 acres, or 80 per cent of the total area planted. For the whole of the Dutch East Indies it appeared that of the total area planted in 1923, 32.3 per cent was British, of the productive area 36 per cent, and of the production 32.4 per cent. For 1924 the figures were 31.9 per cent, 34.9 per cent and 30.9 per cent respectively.

British Percentage.

"From these figures it appears that the percentage of British productive area is higher than that of the total planted, which squares with the higher age of the British plantations. It is, however, remarkable that the British percentage of the total production remains below that of the productive area, the reason being that production per unit is smaller on the British plantations than on the others. In all probability the production of the Dutch East Indies, should restriction be given up entirely, may increase by a figure varying from 5,500 to 12,000 tons. It may be added that the actual figures probably lie nearer the maximum than the minimum.

"Dutch East Indian production was in 1923, 30.8 per cent, and in 1924, 35.1 per cent of the world production; that of the plantations being 21.4 per cent in 1923, and 21.6 per cent in 1924 of the world figure, while native rubber accounted for 9.4 per cent in 1923, and not less than 13.5 per cent in 1924. In the same period the production of Malaya dropped from 45.2 per cent to 40.9 per cent of the world's total.

"Of the planted area of the world, an approximate estimate could be obtained only for plantation rubber, for which the latest figures of the Malay Peninsula were used. At the end of 1923 about 32.3 per cent of the whole was planted in the Dutch East Indies, and in British countries about 64.5 per cent. If to this figure be added the rubber plantations owned by British subjects in the Dutch East Indies, out of a total plantation area amounting to 2,985,500 acres, 2,188,000 acres, or 75 per cent is found to be under British control.

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PLATE I

PLATE II

PLATE III

PLATE IV

PLATE V

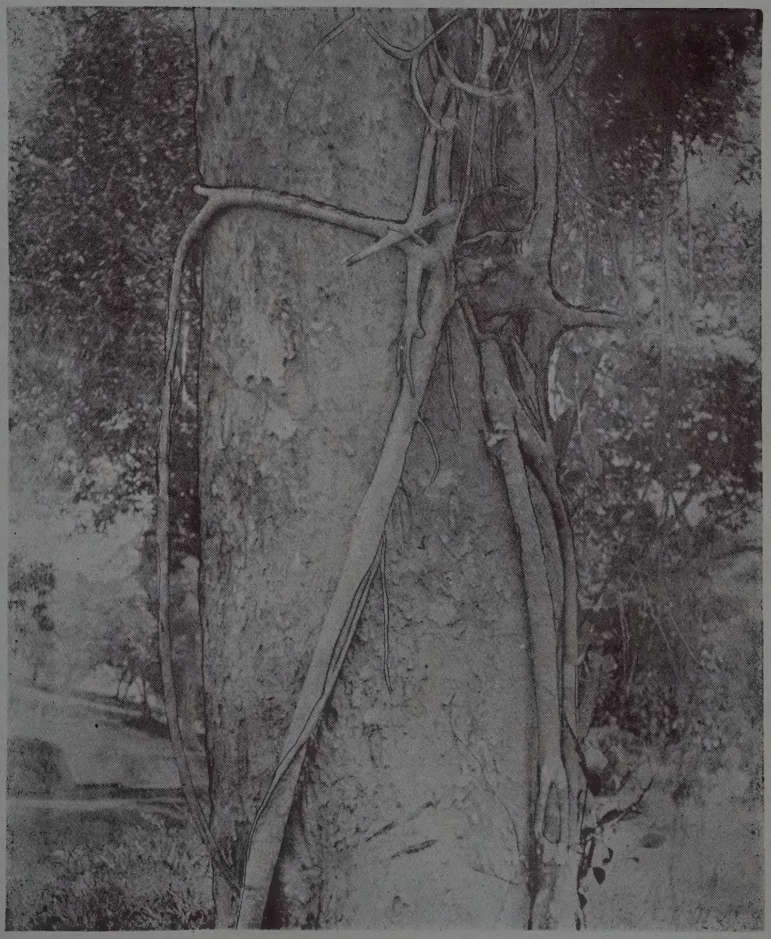

PLATE VI